Prof. Alpheus Hyatt
with the author's regards

NOTES

FROM MY

AQUARIUM

I.—VI.

By GEORGE BROOK, F.L.S.

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No. I.

ITS CONSTRUCTION AND MANAGEMENT.

(Re-printed from "Ashore or Afloat," for July 27th, 1883.)

SINCE the year 1852, when Mr. P. H. Gosse, F.R.S., succeeded in establishing and maintaining for some years a still-water marine aquarium, an unflagging interest has been created in marine aquaria. Year by year improved methods of construction have been devised, until to-day we are in possession of data by which it is easy to study the habits and development of by far the greater portion of our commoner marine animals.

It is not every one who has the opportunity of working in a public aquarium, and as I happened to be one of those, I decided to build an aquarium for myself. Thanks to the kindly advice of Mr. John T. Carrington, of the Royal Aquarium, Westminster, I had little trouble in getting the necessary plans and apparatus. The building which was erected for the purpose is 30 feet by 18 feet, fronting almost due north, and with a square tower at the east end. The north side is devoted to four tanks, made of slate, with glass only at the front. The windows are at the top of the tanks, so that light only enters from above. There is a long tank on the west side, and at one window on the south side there are also two tanks 3 feet by 1 foot, divided by movable partitions, which are used to isolate any special objects of study. Another window on the south side is devoted to a study table, and the east end of the building is taken up by cabinets, bookcase, etc., so as to have everything at hand. The piping, which is of vulcanite, was made by Messrs. Leete, Edwards & Norman, and the system of aeration is as follows:—Under the ground there are two reservoirs holding about 2,000 gallons each, connected together by a three-inch vulcanite pipe. In the tower already spoken of there is a vulcanite pipe, worked by a water-motor; the water is thus pumped out of one reservoir into a tank in the tower about twenty-five feet above the floor of the building; from this we get the fall for aeration in the tanks, and the overflow is returned into the other reservoir. Thus the circulation is complete; and, besides, we are enabled in case of accident to shut off one reservoir, either for repair or for making a fresh supply of salt water. There is a modification of the

ball-tap arrangement fitted to the water-motor, so that whenever the water in the lower tank gets below a certain level, the pump is started, and a fresh supply pumped up. This automatic arrangement works day and night, with only an occasional visit from the attendant.

Three years' experience has shown by this arrangement on an average 1,250 gallons of fresh water have to pass through the motor to pump 850 gallons of sea water into the tower. This is about our daily circulation, and costs in water $7\frac{1}{2}$d.* per day. The salt water is all made artificially, except such as is used to convey live stock from the coast. I used the formula given by Mr. W. H. Jones, who has been so successful at the Aston Park Aquarium, and found the cost to be about one-third of a penny per gallon. After all the chemicals have been added to the fresh water in the proper proportions, the whole was well stirred up every day for ten days or so. The water was then allowed to settle for a couple of days, and then circulated in the tanks for two days more before any live stock was added. By this means the water obtained a brilliancy which is seldom seen in large aquaria. We have never had any trouble with it, and year by year the crystal appearance gets more pronounced, and objects which two years ago could not be kept alive a week, live now quite healthily month after month. I attribute a great part of this success to the constant circulation of the water day and night. The vulcanite jets I had suppled at first I have altogether discarded. The holes, varying from one-sixteenth to three-sixteenths of an inch, were too large and not of the proper shape. Too much water was used by each jet, and the air taken into the tanks by the force of the water was in such large bubbles, that the greater part immediately rose to the surface again without imparting its oxygen to the water. Again, the force of water had to be so strong as to stir up the sediment in each tank, and thus thicken the water. The system I have now adopted gives very different results. A small glass tube of suitable length is drawn out to a fine point for the jet and adapted to the supply pipe by means of an indiarubber stopper. There is a stop-cock to each jet, so that I can regulate the amount of water passing through. The top of the glass tube is within an inch of the surface of the water, and myriads of tiny air bubbles are taken quite to the bottom of the tank. They are so small that they do not rise quickly to the surface, and they can be traced floating gently along six feet from the jet. There are two jets in each tank, but only one is used excepting in very hot weather. The difference in results between this system and the old one

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* This has since been reduced to $3\frac{1}{2}$d. to 4d. by using the arrangements described in Nos. V. and VI.

is marvellous, and requires to be seen at work to be properly appreciated. There is a little filter attached to each jet, but, I may add, this is not an essential point. Fresh water requires adding from time to time to make up for loss from evaporation, and if there are many crustacea in the tanks, a piece of chalk must be kept in one of the reservoirs to compensate for that abstracted from the water for shell making. Having now described in general terms the arrangement of my aquarium, I propose from time to time to give notes of any interesting objects which we may be studying.

No. II.

FISH PARASITES.

(Re-printed from "Ashore or Afloat," for September 28th, 1883.)

In July last Mr. John T. Carrington, F.L.S., of the Royal Aquarium, Westminster, called my attention to the extreme abundance of a parasitic crustacean in the fresh water tanks of that Aquarium. At one time the little creatures appeared in such quantities as to quite obscure the fish in the tanks, and the havoc which they created amongst the fish was something astounding. The little crustaceans belonged, undoubtedly, to the genus *Argulus*, but appeared too large for our British species *A. foliaceus*, Linn. They were of a pale blue green colour, and sufficiently transparent for the general anatomy to be made out with the aid of a microscope. There were many specimens over half an inch long, and it was their unusual size which first made me doubtful as to the species being *A. foliaceus*. The parasites attached themselves under the scales of the fish by means of their two large suckers, bringing on inflammation, and later a maceration of the surrounding tissues, so that the spot occupied by each individual appeared as a small raised white patch. All species of fish in the tank were attacked alike, and an immense mortality resulted. To show the rapidity with which this was accomplished, I am informed that a 16-lb pike was killed in three days. Mr. Carrington, knowing that many of these fish parasites cannot live in salt water, had some of the fish bathed in strong brine, and immersed in sea-water for a short time. Others methods were tried, including the reduction of the temperature of the water with ice. The results, however, were not very satisfactory, for though the attached parasites were usually killed by the salt water treatment, others soon attached themselves, and matters were as bad as ever. The most successful method tried by Mr. Carrington, and indeed the one by which he succeeded in getting rid of the pest, was the introduction of a large number of very fine sticklebacks (*Gasterosteus trachuras*). These fish

devoured the *Arguli* with great greed, and in a few days the tanks were comparatively clear again.

According to Baird, *A. foliaceus*, L. is frequently found parasitic on the stickleback in the South of England, it seems strange therefore that this fish should be made use of to get rid of the same parasite on others. Mr. Carrington kindly sent me some specimens alive for study, and it was then that I found that although there were a few specimens of *A. foliaceus* present, by far the greater number belonged to *A. coregoni* of Thorell. This latter species is readily distinguished from the former by its much greater size, and by having the tail lobes pointed instead of rounded at the apex. As I am not aware that this species has hitherto been recorded as British, I made inquiries as to whether any fish other than those from British waters had been placed in the tanks. It appears that the only foreign fish introduced were some American black bass, all of which had died months before the parasite made its appearance. Now, although there are several species of *Argulus* found in America, most of which are peculiar to it, I am not aware that *A. coregoni* has ever been recorded from there, so that there appears no reason to suspect its introduction here.

For the guidance of those of your readers who may care to follow the subject, I subjoin a summary of the leading characters of the British species of *Argulus*.

A. foliaceus, L. Distinguished by its smaller size (length 6-7 mm., breadth $3\frac{1}{2}$ mm.), by basal joint of second pair of antennæ being armed with a strong spine, and by having apices of tail lobes rounded, Baird (Nat. Hist. Brit. Entomostraca, 1850, pl. 31) does not correctly indicate the basal joint of first pair of antennæ, which does not appear to differ essentially from the same in *coregoni*. Claus, however figures it correctly. Sexual appendages on second, third, and fourth pair of legs of ♂ differ considerably from those of ♂ of *coregoni*. (See Claus, Zeitschr. f. w. Zool. B. 25, 1875, pl. xvii.)

A. coregoni, Thorell. Known by its much larger size—length $10\frac{1}{2}$ (♂) 13 (♀) mm., breadth 8 (♂) $8\frac{1}{2}$ (♀) mm.—by having but a very small projection at base of second antennæ (as Thorell describes but does not so correctly figure), and by having apices of tail lobes lanceolato-accuminate. Habitats (not British) chiefly on the salmonidæ, but Claus has also found it on the sand-eel. (See Thorell, Ofver. Vetsakad. 1864.) Leydig describes another European species *A. phoxini* (Archiv. f. Naturg., 1871) found on *Phoxinus lævis*, but Claus considers it merely a small example of *A. coregoni*, without even any subordinate modifications produced by its different habitat.

No. III.

RARITIES FROM THE YORKSHIRE COAST.

(Reprinted from "Ashore or Afloat," for October 5th, 1883.)

Callionymus Lyra, L., the Dragonet, is recorded in Clarke and Roebuck's "Yorkshire Vertebrata" as "occasionally taken off the coast in deep water, but not common." On the 13th of August I caught two specimens off Redcar with a small trawl net, in four or five fathoms of water. I succeeded in bringing one home alive, but the other died in transit. What struck me as curious about this capture was the comparatively shallow water in which the fish were found. The bottom was sandy, and in the same haul we obtained various flatfish, the lesser weever, the grey gurnard, &c. Dr. Day remarks, in his "Fishes of Great Britain and Ireland," that the adult males of this species prefer deep water (twenty to sixty fathoms), while the females and young are often found nearer in shore, especially in sandy bays and in the mouths of large rivers. This may account for my specimens being found so near in shore. I think the one alive is a female, though the dorsal fin is rather longer than figured by Dr. Day, but not nearly so long as his figure of the male. My specimen is six inches long, so this is probably an immature form.

Eolis Peachii, A. and H. I found one specimen of this pretty little nudibranch on a shell inhabited by a hermit crab, which was covered with zoophytes, polyzoa, &c., brought from Redcar, August 7th, 1883. It agrees with Alder and Hancock's description, except that the dorsal tentacles are about, if not quite, twice the length of the oral tentacles. There appear to be only two species of *Eolis* which have the head broader than any part of the foot, and these are *E. peachii* and *E. nana*. In the former the oral tentacles originate from the margin of the lip, in the latter they are placed rather far back on the head. My specimen has the marginal oral tentacles, so there appears little doubt as to its identity. Colour differs a little from Alder and Hancock's description and figures. ("Nudibranchiate Mollusca, Ray Socy.," plate 10.) There is scarcely a trace of yellow in the general body tint, and the gill cores are more olivaceous, with less of the red tint. Length rather more than $\frac{1}{4}$ inch. I might have considered this a young specimen with colour not fully developed, but that it had laid a mass of ova irregularly placed in a colourless mucus, much resembling Alder and Hancock's figure for *E. concinna*. The yolks had a slight rosy tinge.

Eolis exigua, A. and H. Found several specimens apparently belonging to this species among zoophytes (*Obelia geniculata*,

L., with a stray specimen or so of *Clytia johnstoni*, Alder) and red seaweed growing on the carapaces of several individuals of *Hyas araneus*, brought from Redcar, August 4th, 1883. The specimens observed were of various ages and stages of development, but all very young, the size of the largest being about 1-16th inch, and the smallest not more than half that. The most fully-developed form noticed had five pairs of branchial appendages, the *second* pair well developed, the *fourth* pair also well developed, but a little smaller than the second; *fifth* pair somewhat small; *first* pair very small; and *third* pair between first and fifth in size. (The numbers of the pairs in remarks on earlier stages are taken from this stage.) Younger specimens had *first* pair very small, *fifth* pair small, and *third* pair merely tubercles. Still younger form had both *first* and *third* pair of branchial appendages merely tubercles. In the youngest form observed the *fifth* pair also were little more than tubercles. These pairs of appendages would seem, therefore to develop in the following order;—*second*, *fourth*, *fifth*, *first*, *third*. The members of each pair are opposite or nearly so, and one of them seems often to develop in advance of the other, and remain the larger for some time. In the typical *E. exigua* there are two rows of tentacles on each side of the dorsal line, but I think there can be little doubt that in my specimens the second row is absent merely on account of age, particularly as Alder, in his description, gives "set of five rows of one or two each," presumably meaning on each side, so that the outer row does not appear to be constant, and is always less fully developed than the inner one. The only other species which my specimens might probably belong to is *E. despecta*, A. and H., but this has only eight appendages, and they are markedly alternate—while the dorsal line is waved. The Redcar specimens agree with *E. exigua* in the banding of the branchial processes, though some of the youngest scarcely show it, and are more like *E. despecta*. The tentacles also agree with *E. exigua*, and are quite unlike those of *E. despecta*.

This species has been recorded from the Northumberland coast, and is usually found on *Laminaria* and *Fuci* in shallow water, especially on those fronds that bear *Obelia geniculata*.

No. IV.

NOTES ON THE COLLEMBOLA.

THE PERIOD OF OVIPOSITION OF LEPIDOCYRTUS LIGNORUM. FAB.

On the 12th of February, 1882, a ♀ of the above species was observed in the act of oviposition. The fourteenth egg was in the act of exclusion when seen, and after it had been deposited, the abdomen was wriggled about from side to side a little, and two minutes later the fifteenth egg rapidly made its appearance for about half its diameter. Further movement was so slow that the egg appeared to become stationary until nine minutes after its first appearance, when it was rapidly dropped. The wriggling movement was again repeated, the sixteenth egg made its appearance a minute later, and was dropped at the end of nine minutes. At length thirty-four eggs were laid, and the following is an analysis of observations of time (in minutes):—

No. of Egg.	From Appearance to time of Dropping.	Interval.	Total.
14th egg	—	2	—
15th ,,	9	1	10
16th ,,	9	1	10
17th ,,	9	1	10
18th ,,	9	1+	10+
19th ,,	$8\frac{3}{4}$	...	...
20th ,,	Recorded time between appearance of 20th and that of 22nd was 24 minutes.		12
21st ,,			12
22nd ,,	...	...	...
23rd ,,	...	$1\frac{1}{2}$	...
24th ,,	$9\frac{3}{4}$	$\frac{3}{4}$	$10\frac{1}{2}$
25th ,,	9	$1\frac{1}{4}$	$10\frac{1}{4}$
26th ,,	...	...	...
27th ,,	...	2	...
28th ,,	9	$1\frac{3}{4}$	$10\frac{3}{4}$
29th ,,	$9\frac{1}{4}$	$1\frac{1}{4}$	$10\frac{1}{2}$
30th ,,	$9\frac{1}{4}$	$1\frac{1}{2}$	$10\frac{3}{4}$
31st ,,	9	$1\frac{1}{4}$	$10\frac{1}{4}$
32nd ,,	$10\frac{3}{4}$	3	$13\frac{3}{4}$
33rd ,,	10	3	13
34th ,,	10 ?	...	...

The whole time—from the appearance of the fifteenth egg to the appearance of the thirty-fourth—was 208 minutes, giving an average of nearly eleven minutes for each egg, including interval. The whole thirty-four eggs would, therefore, probably occupy a period of six hours.

First 14	(estimated)	140	minutes.	Average 10
Egg 15—19	(observed)	50	,,	,, 10
,, 20—27	(observed)	88	,,	,, 11
,, 28—34	(observed)	80	,,	,, $11\frac{3}{7}$
		358		

The insect occupied while laying its eggs the usual position when at rest, with its head low and partly hidden by the mesothorax. The abdomen was lifted then lowered again on dropping each egg, and after a period of quiescence the same movements were followed by the raising of the abdomen and the appearance of another egg. The eggs—laid in an irregular heap—were perfectly spherical, white, with a faint testaceous tinge and shining; average diameter ·172 m.m.

EGGS AND YOUNG OF ISOTOMA PALUSTRIS. LBK.

The first batch of eggs observed were a cluster of some thirty or forty laid in an irregular heap, December 23rd, 1881. They were globular, shining and pale testaceous yellow. Three more clusters were laid on the 28th, the eggs in one of which were white with only an exceedingly faint yellow tinge. Amongst other clusters laid about this time, one on the 6th of January, was fulvous, darker and brighter in colour than any of the preceding batches, so that it is evident the colour of the eggs is variable, even when first laid. On the 5th of January the eggs of the first batch (December 23rd) had changed in colour to purplish red, and on the morning of the 10th most of the eggs had hatched out. The young *Isotoma* is pale purplish red, bluish purple on the antennæ There are no markings excepting the dark eye-patch, and a dark spot with fainter streak leading forwards from it, on the posterior part of the head. The head is large in proportion to the body, antennæ short and thick, with the terminal joint much larger than in the adult form. The whole body is covered all over with pale hairs.

EGGS AND YOUNG OF ISOTOMA ARBOREA.—L.

The eggs of *I. arborea* appear to be laid later in the season than those of *I. palustris.* The first batch observed were laid March 20th, 1882, and we had not another cluster laid until March 31st. These eggs were globular, yellow, and shining very much, resembling those of *I. palustris.* On the 9th and

10th of April the first batch hatched out, being 20—21 days in the egg as compared with 16--17 for *I. palustris.* The colour of the recently-hatched larva is pale purplish red; head broader than the thorax, resembling very closely Nicolet's, fig. 15, plate I. (Recherches sur les Podurelles), eyes distinctly on a dark patch, quite visible through the shell before the egg hatches.

The young when a day or two old are intermediate between Nicolet's figure and Packard's (Embryological Studies, Peabody Acad. Plate III., fig. 15). The constriction in all at the commencement of the abdomen is more defined than in Packard's figure, and, except that the head is not quite so broad and the eyes are on an elongate dark patch, Nicolet's figure represents them better. Prothorax is large, as in both figures. The claws of the larval form do not differ appreciably from those of the adult.

The following is a series of measurements of the young in comparison with a typical form :—

	Young.		Adult.
Breadth of head	7	...	13
,, mesothorax	6	...	17
,, metathorax	$6\frac{1}{2}$	...	18
,, 1st abd. segment ...	$5\frac{1}{2}$	...	16
,, widest part of abd.	$6\frac{1}{2}$	...	19
,, antennæ apical joint	$1\frac{3}{4}$	...	2
Total length	24	...	76
Length of head....	$5\frac{1}{2}$	...	14
,, prothorax	$\frac{1}{2}$	...	nil
,, mesothorax	$3\frac{1}{2}$	...	12
,, metathorax	$2\frac{1}{2}$	...	11
,, abdomen	12	...	39
,, antennæ	7	...	20
,, spring	$6\frac{1}{2}$	...	26

It is interesting to note that, while on the average the larva is about one-third the dimensions of the adult, the head in the larva is broader than any other part of the body, while in the adult it is only two-thirds the width of the broadest part of the abdomen. Again, in the larval stage the head is broader than it is long, while in the adult form it is longer than broad.

The prothorax in the young is quite distinct and easily seen from above, but in the adult form it is hidden by a small projection of the mesothorax (the *mesonotum* of Tullberg.) The antennæ in the larva are almost as broad as in the adult, but the length is only in proportion to the body. This species belongs to the short-springed division of *Isotoma, i.e.*, those in which the spring does not reach the ventral tube. In the young this is even more marked, for

while the general proportions of the body are one-third of the adult, the spring at this stage is only one-fourth the size of the mature spring.

THE SUPPOSED YOUNG OF BECKIA ALBINOS.—NIC.

THESE larvæ were found under boards in a greenhouse on the 29th and 30th of December, 1881. They were active and lively in their movements, and kept the antennæ continually vibrating ; pallid white, very shining, ordinarily with greenish or steely-blue reflections, but with occasional tints of purple and red. There are two small dark eye spots. The mesothorax is very flatly arched; antennæ with third joint shorter than second, and only slightly elongate, varying to sub-globular and globular; fourth joint slender and spindle-shaped, equalling in length the second and third together. There would be no doubt about the larvæ being those of *Beckia albinos*, were it not that the adult *Beckia* has no eyes at all, while these have two—one on each side. On the 21st of February, 1882, I had several larvæ of the same kind hatched in confinement from egg collected in the greenhouse. The eggs are white and globular, with long, white, somewhat twisted hairs, which taper towards the apex. There are traces in some of a raised rim at one or both poles, as I have observed in the eggs of *Entomobrya multifasciata* var *lanuginosa*. Can this be the ruptured external envelope of the egg spoken of by Nicolet in his "Recherches," and figured on plate I., figs. 9 and 10?

On the 31st of January, I found a larger individual, white and apparently without eye spots. There seems little doubt of this being a more mature form of those observed a month before, so that the eye spots must have been lost in moulting; but further observation is required to make this certain. This specimen had sub-globular third joints to the antennæ, agreeing with Tullberg's characters of the genus *Cyphoderus* (which includes *Beckia albinos* , in which he draws attention to the very small third antennal joint, almost bullet-shaped. The *dentes* and *mucrones* together are shorter than the *manubrium*.

It is not at all unlikely that the young of *Beckia albinos* should have eyes either before or when they are hatched. The *Collembola* generally are provided with eyes, and it is only in aberrant genera like *Beckia* that they are absent. One would, therefore, naturally expect that the young in the course of their development would follow the course of their ancestors, until such a time as the special modifications of their parents become forced upon them, so to speak, in continuation of the special characters of the species. Thus, it may not be until after the first or second moult that the

young *Beekia* loses it eyes and assumes the mature form. The point is a very interesting one, and will well repay further investigation.

YOUNG OF SMINTHURUS NIGER.—LBK.

In April, 1882, I obtained some very young specimens of what appeared to be *Sminthurus luteus*. The general body colour was yellow, and the outline somewhat that of *S. luteus*. Some days later, however, the specimens had changed their colour. The body was a deep blue black, antennæ legs, and spring yellow. Head fuscous with trace of yellow ground colour, buccal cone dusky yellow; two oblong yellow spots, one on each side, below the inner margin of the eye patch. A specimen was afterwards observed in which the body was all spotted like a leopard; yellow ground colour and dark brown, nearly black, spots. These gradually increased in size until the whole of the body was a deep black. Thus the young are hatched of a pale yellow colour, and the pigment is afterwards developed under the skin, first as small spots, which gradually spread over the whole body.

ECDYSIS OF ACHORUTES PURPURESCENS.—LBK.

Amongst specimens collected a few days previously, and placed in a large flat glass cell for study, a specimen of the above species was observed in the act of ecdysis, on March 15th, 1882. Attention was drawn to the specimen by the white, bleached looking apices of the legs and antennæ, due, in fact, to these organs being already partly withdrawn from the skin about to be cast. When first observed there was no other visible change, nor any violent struggling. Soon, however, a split took place along the dorsal line of the thorax. The animal then began writhing and twisting about, and continually doubling its head under its body. These movements were continued until (as far as could be observed from a dorsal view) the head and antennæ had been entirely forced from the old skin. The abdomen was now withdrawn, as well as the legs and spring—the latter when caught sight of, owing to the animal rolling on its side in its struggles, was directed backwards. The animal, before finally clear of the old skin, was laid on its back. After the skin was completely detached, the animal continued for some time the writhing, and rolled about on the surface of a piece of bark. This was probably owing to the legs not having recovered from the shock, and to their consequent inability to obtain a footing. The spring continued to be directed backwards for some time after the operation was complete.

No. V.

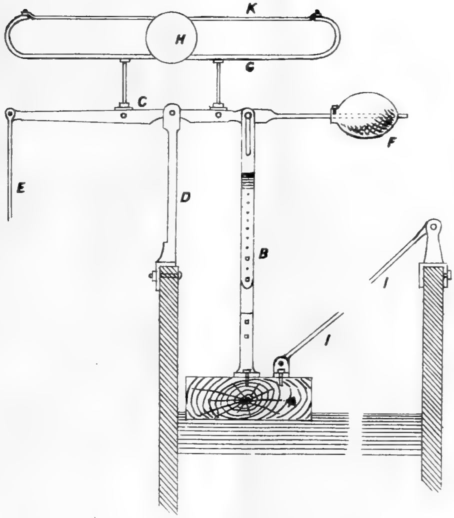
AN AUTOMATIC STOP MOTION FOR A WATER MOTOR.

Figure 1.

We use as a motor for working our pump one of Ramsbottom's Water Motors, worked by the Town's pressure of water, and in the tower-tank we have an arrangement for stopping the motor when the tank is full, and starting it again when down at a certain level. We have tried several modifications of the principle on which the ball tap works with varying degrees of success, until we arrived at the one about to be described, which acts perfectly.

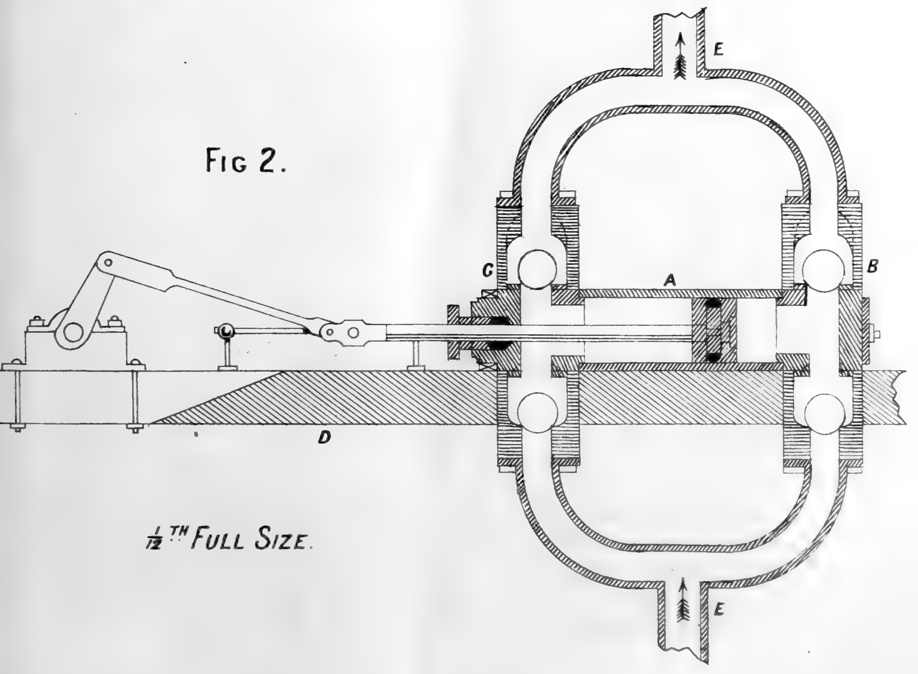
A. is a wood float connected by an adjustable arm B. with the lever C., which is supported on the edge of the tank by the pillar D. In use it was found that the float A., on being forced up by the water, was liable to leave the side of the tank, so that a double-jointed arm I.I., was fixed on the opposite side to keep it in its place. E. represents the arm which goes down to the tap, and F. is a weight corresponding to that of the long rod E., so as to balance the arrangement. As the float A. is forced up, of course, E. is lowered to a corresponding degree, and would be gradually shutting off the tap of the motor unless steps were taken to prevent this being done until the tank was full. It will be observed, however, that the arm B. is slotted at its upper end, so that the float does not begin to press on the lever until it has risen through a distance corresponding with the length of the slot. A similar slot is made where the rod E. is connected with the lever of the tap, and both these slots are adjustable so that at the time the lever over-balances the tank is full, and the time has arrived for the motor to be stopped. This was done gradually at first, but it was found that with a rotary pump, a time arrived when the motor was working so slowly that the pump had not power enough to lift the water the required height, and thus went on wasting power until the level of water in the tank had been sufficiently lowered to start the pump more vigorously. To avoid this the present system was devised where, instead of having an arm with a weight like F. directly over the fulcrum of the lever C., a flat bar of iron G., about 2in. wide, is supported over C. by two pillars, and turned up at both ends so as to prevent the rolling weight H. from falling off. This weight is made from a solid piece of iron and turned out in the middle, so as to leave a flange hanging over G. on each side. For further safety a light rod K. connects the two ends of G., so that there is no chance of the weight H. falling off. It will be seen that as soon as ever the lever C. is in the

Fig 1.



1/16TH Full Size.

Fig 2.



1/12TH Full Size.

slightest over the equilibrium, the weight H runs along the bar G., and shuts or opens the tap instantly.

This arrangement has now been in work some months, and gives every satisfaction. It is allowed to work day and night, and has always started or stopped the motor at the proper time.

No. VI.

ON AN IMPROVED PUMP FOR SALT WATER.

Figure 2.

Three or four years ago when my aquarium was built, I had one of Leete, Edwards and Norman's rotary vulcanite pumps supplied, along with all the piping to fit up the tanks. It has been working intermittently day and night ever since, so that it has been fairly tested. Some months ago I made up my mind to give it up, and use a double-action lift-and-drive dump in its stead, for the following reasons:—

1. I was given to understand I should require less power to lift the same quantity of water.

2. Whenever the water motor was working below a certain speed, there was not enough force to lift the salt water into the tower tank, and thus the motor was working without the pump doing its work. By the new arrangement the shaft of the water motor is connected directly with the piston of the pump, so that if the motor moves ever so slowly the pump must move with it.

3. Sometimes the cups of the rotary pump would catch together, and stop all the apparatus until we could get a mechanic to take the pump to pieces.

By our new arrangement these difficulties are avoided; we get more regular pumping, and an economy in cost of turning.

The working plans were made for me by my friend, Mr. J. T. Nelson, of Leeds, and the work was mostly carried out in our workshop. The general construction will be understood by a glance at the sketch. A. is a bored glass cylinder, obtained from Messrs. Chedgey. The piston rod is of iron covered with vulcanite; while the piston itself is made of *lignum vitæ*, with a round india rubber ring in the centre to form perfect contact. The ends B. and C. are also of *lignum vitæ*, and the round ball valves are of india rubber weighted in the centre with lead. The whole is bolted to a plank D., and connected with the shaft of the water motor in the ordinary manner. The pipes E. E. are of iron lined with glass, and supplied by Messrs. Chedgey. It will be easily seen from the sketch that a stroke in either direction both fills the cylinder from below, and drives the water already in the cylinder into the tower tank.

Huddersfield,
February 28th, 1884.